

NEW AND INTERESTING SPECIES OF *GEMMABRYUM* J.R. SPENCE & H.P. RAMSAY (BRYACEAE, BRYOPSIDA) FROM CALIFORNIA AND THE WEST

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ABSTRACT

Three species in the genus *Gemmabryum* J.R. Spence & H.P. Ramsay are described and illustrated. Two species, *G. brassicoides* J.R. Spence & K.M. Kellman and *G. vinosum* J.R. Spence & K.M. Kellman, are new to science. The third species, *G. californicum* (Sull.) J.R. Spence, previously considered to be part of *G. dichotomum* (Hedw.) J.R. Spence & H.P. Ramsay, is re-instated as a full species due to its highly unusual bulbil morphology. *Gemmabryum vinosum* is distributed in California, Oregon, and Montana, while the other two species are endemic to California.

Key Words: *Bryum*, California Floristic Province, *Gemmabryum brassicoides*, *Gemmabryum californicum*, *Gemmabryum vinosum*, mosses.

Recent fieldwork in California has revealed the presence of many new and interesting species in the Bryaceae. Two species, in *Imbribryum* Pedersen and *Ptychostomum* Hornschuch, have been described elsewhere (Spence and Shevock 2012, 2015). Among the remainder are several species in the genera *Gemmabryum* J.R. Spence & H.P. Ramsay, *Plagiobryoides* J.R. Spence, and *Rosulabryum* J.R. Spence. Within the genus *Gemmabryum* there are four undescribed species, two of which have been known about for several years with many collections made, and an additional two recently discovered species. In this paper we describe the two well-known new species of *Gemmabryum*, one of which appears to be endemic to California. We also describe and discuss an interesting species that has been previously ignored by earlier workers. These new species increase the described *Gemmabryum* flora of California to 17 (cf. Norris and Shevock 2004).

*Gemmabryum* was described for those species with stems not julaceous, heterogeneous laminal areolation, the presence of leaf axil bulbils and/or rhizoidal tubers, leaves typically lacking a limbidium, and small size (Spence and Ramsay 2005). The genus includes two groups, one consisting of the tuber-forming species centered around *G. subapiculatum* (Hampe) J.R. Spence & H.P. Ramsay, and the second consisting of the bulbil-forming species centered around *G. dichotomum* (Hedw.) J.R. Spence & H.P. Ramsay (= *G. bicolor* [Dickson] J.R. Spence). This latter group includes the type species *G. pachytheicum* (Müll. Hal.) J.R. Spence & H.P. Ramsay. The distinctions between these groups are not always clear-cut, as a few species produce both bulbils and

tubers, such as the pantropical *G. exile* (Dozy & Molk.) J.R. Spence & H.P. Ramsay. Also, a few species, which morphologically appear to belong to the bulbil-forming group, do not produce bulbils, at least in the wild, and occasionally produce rhizoidal tubers. The genus appears to be closest to *Bryum* Hedw. and *Imbribryum* Pedersen. Recent molecular work (Holyoak and Pedersen 2007) has suggested that *Gemmabryum* includes at least two major clades, corresponding to the bulbil- and tuber-forming groups. The tuber-forming clade may be phylogenetically closer to *Imbribryum* than it is to the bulbil-forming clade. In addition, Holyoak and Pedersen (2007) also determined that the large-tuber forming species *B. bornholmense* Wink. & R. Ruthe and *B. rubens* Mitt. were closest to *Rosulabryum capillare* (Hedw.) J.R. Spence, a placement supported by several additional morphological characters. Elsewhere, these two species have been transferred to *Rosulabryum* (Spence 2009). Until a more thorough molecular analysis including many more species in this group is available, we have retained the original concept of *Gemmabryum sensu* J.R. Spence and H.P. Ramsay (Spence and Ramsay, 2005), retaining within the genus the tuber-bearing species. One of the species discussed in this paper belongs to the bulbil-forming group that includes the type of the genus, while the other two cannot be easily assigned to either group.

TAXONOMIC TREATMENT

***Gemmabryum brassicoides*** J.R. Spence & K.M. Kellman. sp. nov. (Fig. 1).—Type: USA,

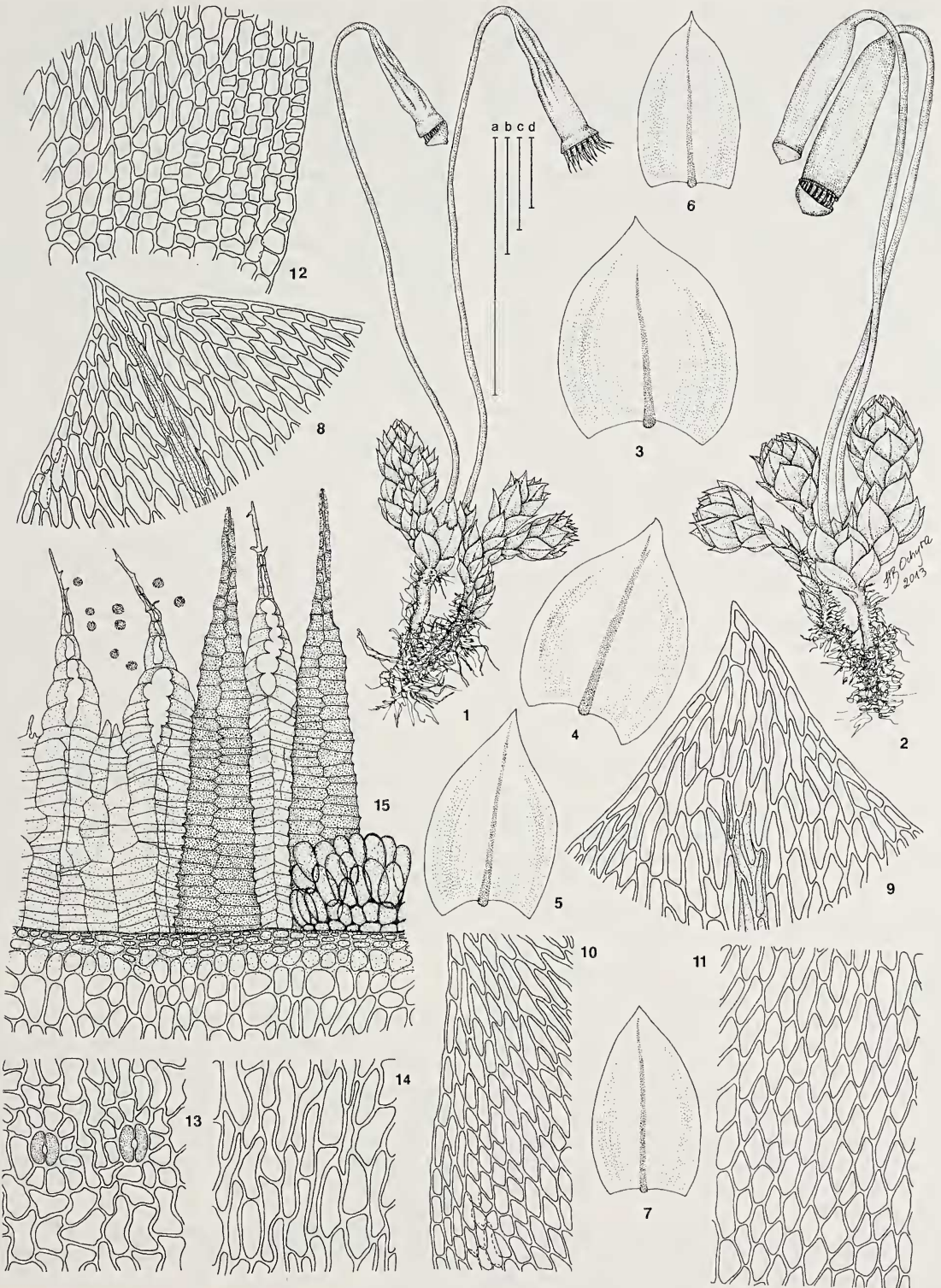


FIG. 1. *Gemmabryum brassicoides* J.R. Spence & Kellman. 1. Fertile plant, dry. 2. Same, wet. 3-7. Leaves. 8-9. Leaf apices. 10. Mid-leaf cells at margin. 11. Mid-leaf cells. 12. Basal cells. 13. Exothecial cells at base of urn and stomata. 14. Mid-urn exothecial cells. 15. Exothecial cells at orifice, annulus, portion of peristome, and spores. (All from Kellman & Shevock 5184, isotype, KRAM). Scale bars: a - 1 mm (3-7); b - 100  $\mu$ m (8-12); c - 100  $\mu$ m (13-15); d - 1 mm (1-2).



California, Santa Cruz Co., Quail Hollow Ranch County Park, on vertical sandstone roadbank on the west side of Quail Hollow Rd across from the ranch buildings, live oak forest with ponderosa pine and chaparral, 18 Mar 2006, 160 m, 37°04'57"N, 122°03'50"W, *Kellman 5104* (holotype: CAS).

*Plantae virides vel flavo-virentes, gemmiformes, foliis late ovatis, costa percurrenti vel in mucronem brevi-excurrenti, cellulis laminae distalibus parietibus crassis praeditis, structuris reproductivis peculiaribus asexualibus nullis; capsula cylindracea, peristomio perfecto.*

Plants small, to three mm tall, short-rosulate, sometimes in annual comal tufts, rarely evenly foliate, with the apical coma ovoid or spherical. Stems with distinct central strand, sclerodermis 1–2 cells thick with red cell walls, sparsely rhizomatous, rhizoids brown. Leaves 0.55–0.78 × 0.42–0.54 mm, ca. 1.25:1; tightly appressed both wet and dry, broadly ovate, somewhat concave. Apex broadly obtuse to acute-mucronate. Margins weakly reflexed in proximal half, entire, without a border of differentiated cells. Costa subpercurrent to excurrent into a mucro, sometimes spurred or branched near the apex. In section at midleaf elliptical, not particularly prominent on either surface, with two guide cells on the ventral surface only, a central stereid band, and a dorsal epidermis of enlarged cells. Distal laminal cells with yellowish, moderately thick walls, at least in the outer comal leaves, hexagonal 2–3(4):1, 40–56 × 14–25 μm. Proximal laminal cells quadrate to short rectangular 1–1.5(2):1, 20–30 × 18–22 μm. Asexual reproductive structures not seen. Sexuality polyoicous. Gametangia terminal, leaves similar to vegetative leaves although somewhat smaller. Seta 8–11 mm, pale red to yellow with age, smooth throughout. Capsule horizontal to nodding, dark red when mature, cylindrical, 1.8–2.2 mm long, neck about 1/3 the total length, slightly wrinkled when dry. Exothelial cells irregular, irregularly quadrate at the mouth with thick red walls, stomata restricted to the neck. Operculum short conical. Exostome narrowly triangular, filiform at the apex, pale orange, finely papillose, trabeculae prominent. Endostome hyaline, basally united for 1/2 the length, with or without perforations, gradually and irregularly reduced to unornamented filaments, cilia absent. Spores 10–14 μm, smooth, with an easily visible large organelle.

Paratypes: USA, CALIFORNIA. **Contra Costa Co.:** Hills west of Vasco Rd about four miles west of Byron, 250 m, 37°48'00"N, 121°42'30"W, 19 Mar 1997, *Shevock, O'Brien & Jessup 15024* (CAS). **Fresno Co.:** Trimmer Springs Rd above Pine Flat Reservoir, 365 m, 36°53'00"N, 119°17'45"W, 25 Mar 1996, *Shevock, Norris & Barahona 13164* (CAS); Sierra National Forest, off Cripe Rd 0.65 mile from Peterson Mill Rd,

1090 m, 37°02'30"N, 119°21'15"W, 16 Mar 1997, *Shevock & York 14946* (CAS). **Madera Co.:** Co. Rd. 29 across from Eastman Lake Visitor Ctr., 150 m, 37°13'00"N, 119°58'30"W, 15 Mar 1997, *Shevock 14934* (CAS); USDA San Joaquin Experimental Range, 985 ft, 37°04'53"N, 119°43'44"W, 25 Mar 2009, *Shevock 32638* (CAS). **Monterey Co.:** Fort Hunter Liggett, the Palisades off the Gabilan Rd, 330 m, 35°52'N, 121°13'W, 10 Apr 2004, *Kellman et al. 3764* (CAS). **San Luis Obispo Co.:** Saucito Springs, Carrizo Plain about four miles south of Soda Lake, 2300 ft, 35°09'45"N, 119°53'30"W, 7 Feb 2001, *Laeger, Carter & Butterworth 677* (CAS). **Santa Barbara Co.:** Los Padres National Forest, off Stagecoach Rd below Cold Springs Arch Bridge, 425 m, 31°40'N, 119°50'W, 26 Mar 2006, *Norris & Hillyard 108820* (UC) and *Shevock 27868* (CAS); west of San Marcos Pass along West Camino Cielo Rd, 2900 ft, 34°30'07"N, 119°51'56"W, 26 Mar 2006, *Shevock, Norris & Spence 27885* (CAS). **Santa Cruz Co.:** Quail Hollow Quarry, 150 m, 37°05'N, 122°04'W, 18 Aug 1996, *Kellman 296* (CAS); Quail Hollow Ranch County Park, 195 m, 37°05'N, 122°03'W, 29 Apr 2000, *Kellman 953* (CAS); Hilton Meadow at the end of Lucilles Ct. off SR 236 north of Boulder Creek, 260 m, 37°08'N, 122°09'W, 8 Apr 2000, *Kellman 931 & 7183* (CAS); Doyle's Meadow off Hwy. 9, 0.75 mile north of Boulder Creek bridge, 175 m, 37°08'N, 122°07'W, 15 Oct 2000, *Kellman 1154* (CAS). **Solano Co.:** Indian Spring two miles north of Rockville off Rockville Rd, elevation and lat-long not given, 27 Feb 1975, *Weber 48291* (COLO). **Tulare Co.:** Generals Hwy near entrance station above Three Rivers near Sycamore Creek, 440 m, 36°29'00"N, 118°50'15"W, 4 Apr 1998, *Shevock & Whitmarsh 16992* (CAS).

#### HABITAT AND ECOLOGY

Forming turfs on sandstone walls near the coast, and rarely on metamorphic rock and granite in the interior, on outcrops in chaparral and ponderosa pine parkland, or in the transition between chaparral and oak woodland, to 400 m in elevation, and endemic to California. The plant grows in generally sunny locations where the substrate is moist in winter, but dry in the summer.

Associated bryophytes are *Cephaloziella divaricata* (Sm.) Schiffn and *Grimmia trichophylla* Gray.

#### ETYMOLOGY

The name derives from the general look of the plants in the field similar to a tiny head of cabbage (*Brassica oleracea* L.).

## DISCUSSION

The only other *Gemmabryum* with leaves that remains erect-appressed wet or dry is *G. californicum*. If capsules are present, separation is easy, as *G. brassicoides* has cylindrical capsules, and *G. californicum* has short-ovoid capsules. Without capsules, or gemmae, the identification becomes more difficult and in certain cases nearly impossible. *Gemmabryum californicum* has distal laminal cells that are sometimes thick walled, but often have thin walls, whereas *G. brassicoides* distal laminal cells are always thick walled. A more subtle difference is in the shape of the terminal coma, with *G. brassicoides* being more commonly spherical but occasionally ovoid, while *G. californicum* is more commonly ovoid, but rarely spherical. Thus, if the apex of the plant is bluntly rounded, it is more likely *G. brassicoides*.

There are several interesting and unusual features regarding this species. First, it is common in lowland fire-adapted chaparral communities, and appears to be able to survive at least some fires. Secondly, it was originally thought to be dioicous like most other species of *Gemmabryum*, but male plants were not known. Recent laboratory studies (L. Stark, pers. com.) have revealed that at least the cultivated material of *G. brassicoides* is polyoicous, with synoicous, male and female shoots, which is extremely rare in the genus. Field collections need to be made to determine whether the species is typically mixed in populations and what environmental variables are associated with sex expression.

## TAXONOMIC TREATMENT

***Gemmabryum vinosum*** J.R. Spence & K.M. Kellman. sp. nov. (Fig. 2).—Type: USA, California, Fresno Co., BLM San Joaquin River Gorge Management Area, along river via a 0.25 mi. trail from powerhouse and parking lot, R22E, T10S, section 10, NAD 83, 37°04'37"N, 119°33'43"W, 600 ft, 26 Mar 2009, *Shevock, Kellman & Lodder 32676* (holotype: CAS; isotypes: H, KRAM, MO, NY, UC).

*Plantae quoad affinitatem ignotae, rubrae vel burgundiacae-vinosae, gemmiformes, saepe in caespitibus interruptis duobus vel pluribus, foliis ovatis, in aristam laevum, distaliter hyalinam excurrentibus, in statu sicco subdivertgentes, cellulis laminae distalibus saepe pallidis vel hyalinis, tuberculis rhizoidalibus interdum praesentibus, rubro-brunneis, sphaericis, capsula cylindrica, peristomio reducto, ciliis nullis.*

Plants small, up to one cm tall, more or less rosulate, or with annual comal tufts, rarely evenly foliate, burgundy-red and somewhat shiny when dry, or rarely olive-green. Usually simple, but

sometimes branched. Innovations gemmiform to rosulate. Stems with a distinct central strand. Rhizoids reddish-brown, papillose. Rhizoidal tubers rare, reddish brown, 70–140  $\mu$ m in largest dimension, cells not protuberant. Stem leaves usually remote, lanceolate, gradually getting broader toward the apex. Comal leaves tightly appressed when dry, erect when moist; red throughout (especially in the outer leaves) or at the distal end of the leaf, ovate to obovate, 1.0–1.2  $\times$  0.6–0.7 mm. Axillary hairs of one basal short rectangular brown cell and 3–4 linear, hyaline cells. Distal laminal cells generally hexagonal, 60–76(90)  $\times$  20–24(26)  $\mu$ m, 2.5–4:1; moderately thick walled but not porose. Proximal laminal cells generally quadrate to short rectangular, 1–2:1. Costa strong, excurrent into a smooth to slightly denticulate awn that is proximally concolorous with the upper leaf, but apically paler and appearing straw colored or hyaline and somewhat divergent when dry; costa in section with a strong abaxial epidermis, a central stereid band, and a ventral epidermis, rarely with a single layer of guide cells and an angular opening similar to a degraded hydroid strand dorsal to the guide cells. Margins recurved in the basal half, plane above, entire throughout, marginal cells of similar length to interior cells, but narrower, forming a weak limbidium. Asexual reproduction by rhizoidal tubers. Sexual condition dioicous, seta red, smooth, 13 mm long. Capsule cylindrical, three mm long, nodding, red when mature, wrinkled when dry, neck thick, about equal to the theca. Exothelial cells generally elongate, irregularly shaped, becoming shorter toward the mouth. Stomates restricted to the neck. Operculum conical. Annulus of 2–3 layers of vertically elongated, shingled cells, the inner cells remaining on the capsule, the outer cells falling with the operculum. Exostome pale yellow granular but not papillose, about 0.3 mm long. Endostome hyaline, basally united for about 1/2 the length, segments fenestrate, cilia appendiculate total length equal to the exostome. Spores smooth, 12–16  $\mu$ m in largest dimension.

Paratypes: USA, CALIFORNIA. **Butte Co.:** South Table Mountain, 1096 ft, 39°33'01"N, 121°32'52"W, 10 Apr 2003, *Ahart 10081* (CAS, CHSC), Table Mountain, 447 m, 26 Mar 2011, *Hutten 15296* (CAS); Bidwell Park, along creek at diversion dam site in open grassland with blue and valley oaks along Big Chico Creek, 120 m, 39°46'43"N, 121°44'57"W, 21 Apr 2006, *Norris & Shevock 108860 & 108855* (UC) and *Shevock & Norris 27901* (BOL, CAS, DUKE, KRAM, MO, NY, RSA, UBC, UC). **Colusa Co.:** On roadside bank off SR 16 northeast of Rumsey near mile marker 5.46, 200 m, 39°18'N 122°19'W, 21 Mar 2003, *Kellman 2739a* (CAS). **Contra Costa Co.:** Mt. Diablo State Park, below observation deck of Mt. Diablo Peak, 3800 ft, 37°52'55"N,



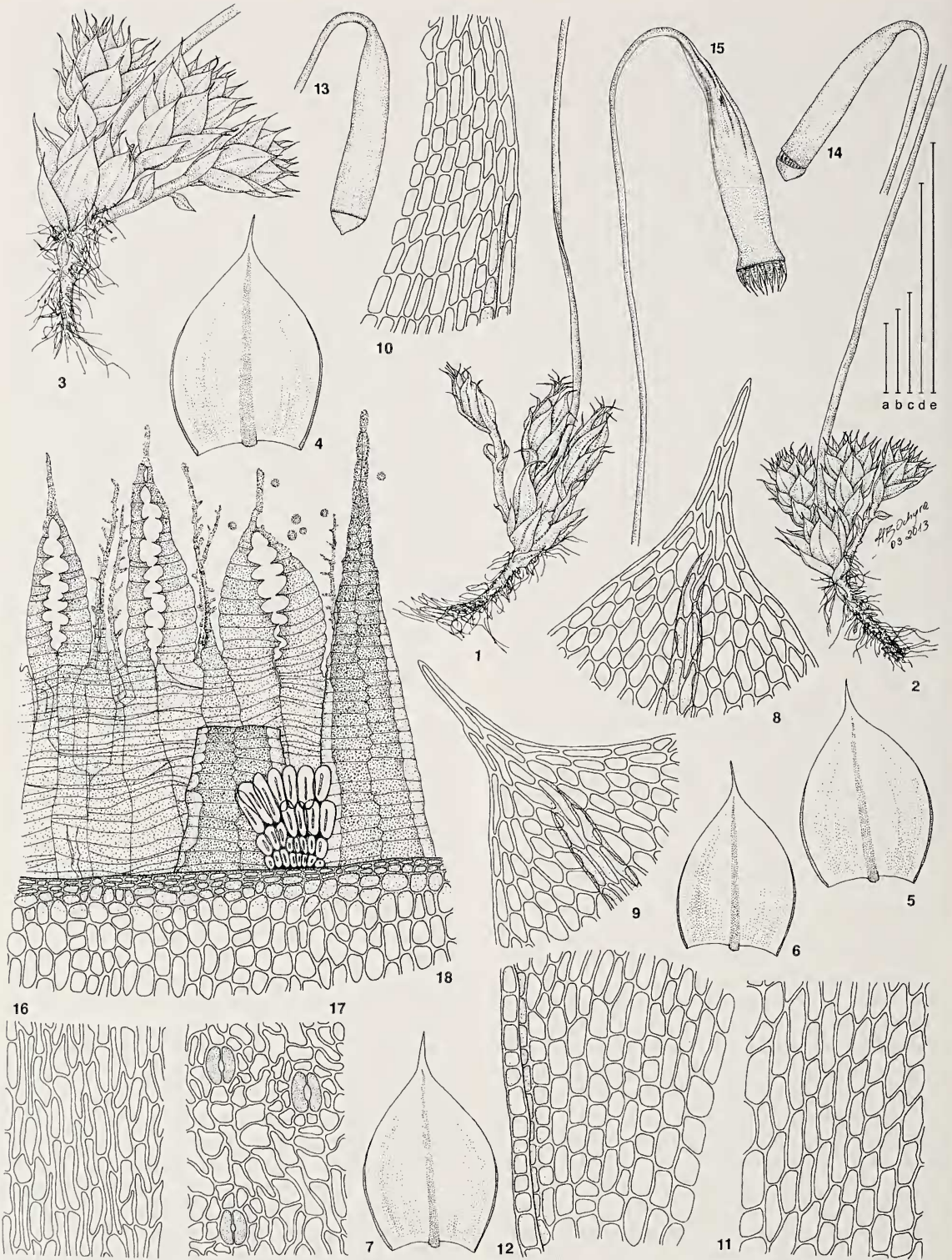


FIG. 2. *Gemmabryum vinosum* J.R. Spence & Kellman. 1. Fertile plant, dry. 2-3. Same, wet. 4-7. Leaves. 8-9. Leaf apices. 10. Mid-leaf cells at margin. 11. Mid-leaf cells. 12. Basal cells. 13-14. Operculate capsules, dry. 15. Deoperculate capsule, dry. 16. Mid-urn exothelial cells. 17. Exothelial cells at base of urn and stomata. 18. Exothelial cells at orifice, annulus, portion of peristome and spores. (All from *Shevock 32676*, isotype, KRAM). Scale bars: a - 1 mm (1, 3, 13, 15); b - 100 μm (16-18); c - 100 μm (8-12); d - 0.5 cm (2, 14); e - 1 mm (4-7).



121°52'55"W, 28 Feb 2004, *Shevock & Game 24635* (CAS); Flicker Ridge, 1035 ft, 37°49'52"N, 132°09'34"W, 1 Mar 2007, *Shevock et al. 29452* (CAS). **Fresno Co.:** from the type locality, *Hutten 14331* (CAS) and *Kellman, Shevock & Lodder 6087* (CAS); forest road 8S05 above the San Joaquin River, Sierra National Forest, 2500 ft, 37°12'25"N, 119°19'40"W, 21 Mar 2001, *Shevock & Norris 20633* (CAS), *Shevock & Norris 20642* (CAS, KRAM); Cripe Rd, Sierra National Forest, 3580 ft, 37°02'30"N, 119°21'15"W, 16 Mar 1997, *Shevock & York 14963* (CAS, MO, NY). **Kern Co.:** northern slopes of Cross Mtn. above Jawbone Canyon and Cottonwood Creek ca. six miles west of California Hwy 14, 1050 m, 35°17'30"N, 118°08'00"W, 21 Mar 1998, *Shevock, York & Hare 16913* (CAS). **Lake Co.:** Manning Creek where it nears Hwy 175 approximately four miles west of Lakeport, 445 m, 38°59'45"N, 122°56'32"W, 25 Mar 2002, *Kellman 2223* (CAS), and *Shevock & Mishler 21925* (CAS); along Hwy 53 about one mile south of Hwy 20, 1650 ft, 3 Apr 1976, *Norris 47656* (UC); Morgan Valley Rd, 1300 ft, 38°54'00"N, 122°35'00"W, 3 May 2004, *Toren 9331* (CAS); south base of Elk Mountain, Mendocino National Forest, 1500 ft, 39°15'35"N, 122°15'35"W, 21 Feb 2005, *Toren 9352a* (CAS); Harrington Flat Rd east of Boggs Lake and south of Mt. Hannah, 3000 ft, 38°52'15"N, 122°45'33"W, 17 Apr 2005, *Toren & Dearing 9399* (CAS); south bank of Eel River below forest road M1 and Logan Spring, 1800 ft, 39°24'30"N, 122°58'20"W, 19 Jun 2013, *Toren & Dearing 10087a* (CAS, DUKE, MO, NY). **Madera Co.:** Eastman Lake Visitor Center, 500 ft, 37°13'00"N, 119°58'30"W, 15 Mar 1997, *Shevock 14934a* (CAS); USDA San Joaquin Experiment Range, 985 ft, 37°04'53"N, 119°43'44"W, 25 Mar 2009, *Shevock 32635* (CAS, MO, NY) and *Hutten 14303* (CAS); Nelder Redwood Grove, Sierra National Forest, 4950 ft, 37°25'31"N, 119°34'22"W, 1 Jul 2013, *Shevock & Ma 42700* (CAS); slopes at south end of Bass Lake Recreation Area, Sierra National Forest, 3275 ft, 37°16'59"N, 119°32'07"W, 24 Mar 2009, *Shevock, Norris & Hillyard 32627* (CAS, CONN, F, HO). **Mariposa Co.:** Yosemite Valley, Yosemite National Park, 1280 m, 26 Aug 1966, *Flowers 6582* (COLO); Devils Gulch, South Fork Merced River, Sierra National Forest, 2000 ft, 18 Apr 2010, *Hutten 14911* (CAS), and *Hutten 14922* (CAS); BLM Merced River Wild & Scenic River Area, Hwy 140 at Slate Creek Bridge, 1440 ft, 37°38'05"N, 119°56'02"W, 6 Apr 2013, *Shevock & Dalton 41988* (CAS); slopes above Merced River along Moss Creek, Stanislaus National Forest, 2280 ft, 37°40'38"N, 119°48'21"W, 10 Apr 2010, *Shevock, Colwell & Hutten 34822* (CAS, KUN, VBG1) & *Hutten 15334* (CAS); slope above Rancheria Flat, 1815 ft, 37°40'18"N, 119°48'27"W, 3 Apr 2011, *Shevock & Hutten 37612* (CAS); along Hwy 140 at Merced River Bridge, El Portal, 1815 ft, 37°40'18"N, 119°47'38"W, 3 Apr 2011, *Shevock & Hutten 37643* (CAS, MO, NY); Yosemite National Park, Foresta Rd just south of Rancheria Flat, 1770 ft, 37°40'10"N, 119°48'31"W, 3 Apr 2011, *Shevock & Hutten 37647* (CAS, MO, NY). **Mendocino Co.:** south end of Black Butte River Bridge, 2680 ft, 39°47'58"N, 123°04'34"W, 21 Oct 1998, *Harpel & Toren 18654* (CAS). **Monterey Co.:** Zmudowski State Beach dunes, 5 m, 36°50'24"N, 121°48'13"W, 15 March 2009, *Kellman & Lodder 6032* (CAS); Los Padres National Forest off Indians Rd, 715 m, 36°30'30"N, 121°27'49"W, 3 Apr 2004, *Kellman 3676* (CAS); near Canogas Falls south of Devils Creek Canyon, 500 m, 36°04'12"N, 121°33'14"W, 25 Mar 2006, *Kellman & Shevock 5018* (CAS); Wagon Caves, 1500 ft, 36°05'00"N, 121°24'05"W, 22 Mar 2004, *Shevock, Dearing & Game 24740* (CAS); south of Santa Lucia Memorial Park, 2325 ft, 36°06'32"N, 121°27'43"W, 3 Apr 2004, *Shevock & Kellman 24801* (CAS). **Nevada Co.:** Spenceville Wildlife Management Area, 400 ft, 39°07'05"N, 121°15'39"W, 4 May 2005, *Ahart 11586* (CAS, CHSC); Tahoe National Forest, near the south fork of the Yuba River at the Golden Quartz picnic area about five miles east of Washington, 800 m, 39°21'N, 120°44'W, 10 Sep 2001, *Norris & Hillyard 102889* (UC). **Plumas Co.:** Plumas National Forest, Mt. Hough Rd, 30 Mar 2004, *Dillingham 1394* (CAS). **San Benito Co.:** Pinnacles National Monument, 435 m, 36°29'10"N 121°12'12"W, 5 Mar 2005, *Kellman, Shevock & Villasenor 4242* (CAS) and *Shevock, Kellman & Villasenor 26346* (CAS); Balconies Trail, 1550 ft, 36°29'53"N, 121°12'18"W, 12 Feb 2005, *Shevock & Hurley 26296* (CAS). **San Diego Co.:** along Hwy 94, ¼ mile northeast of Dulzura, 275 m, 32°39'09"N, 116°47'27"W, 24 Mar 2013, *Kellman & Lodder 7098* (CAS); Balboa Park, 81 m, 32.73504°N, 117.15822°W, 5 Mar 2013, *Marshall 1172* (CAS), *Marshall 1174* (CAS), *Marshall 1177* (CAS, SD). **San Luis Obispo Co.:** in open oak forest along Pozo Rd ca 1.5 miles west of Hwy 178 at La Panza Ranch, 490 m, 35°22'N, 120°12'W, 27 Dec 1979, *Norris 55145* (UC). **San Mateo Co.:** On wood roof of garage, Los Altos Hills, 18 May 1983, *W.B. Shofield 81394* (private herbarium of JR Spence); **Santa Clara Co.:** near Pacheco Creek at Hole in the Rock just west of Kaiser-Aetna Rd in Henry Coe State Park, 240 m, 37°07'N, 121°22'W, 19 Apr 1998, *Whittemore & Briggs 6619* (CAS, MO). **Shasta Co.:** along Pit River at Potem Falls northwest of round Mountain, 400 m, 40°50'N, 122°00'W, 2 May 1991, *Norris 76355* (UC); Whiskeytown National Recreation Area along Clear Creek, 950 ft, 40°35'05"N, 122°32'59"W, 23 Mar 2003, *Shevock, Toren & Dearing 23847* (CAS). **Stanislaus Co.:** Henry Coe State Park, southern part of the



Orestimba Creek trail on the north side, 410 m, 37°11'N, 121°24'W, 18 Apr 1998, *Whittemore & Briggs 6591* (CAS, MO). **Tehama Co.:** Antelope Creek Canyon near the microwave station ca 10 miles east of Red Bluff on Bell Mill Rd, 210 m, 19 Jan 1971, *Berti 419b* (UC). **Tulare Co.:** Kaweah River below confluence with South Fork Kaweah River, 800 ft, 36°25'00"N, 118°55'00"W, 13 Apr 1999, *Shevock 17856* (CAS); along Shepard Peak Rd, 2000 ft, 36°29'30"N, 118°50'30"W, *Shevock & Whitmarsh 17019* (CAS); Sequoia National Park, off of Generals Hwy near Ash Mountain Headquarters, 490 m, 36°29'N, 118°49'W, 4 Apr 1998, *Shevock & Whitmarsh 17029* (CAS); Kern River near confluence of South Fork Creek, Sequoia National Forest, 3800 ft, 35°58'00"N, 118°29'09"W, 26 Apr 2002, *Shevock, Laeger & Carter 22080* (CAS, DUKE, H, KRAM, RSA, UBC); Bear Creek Rd below Mt. Home State Forest, 5200 ft, 36°11'15"N, 118°43'30"W, 27 Mar 1996, *Shevock, Norrris & Barahona 13204* (CAS); Terminus Reservoir near Three Rivers, 700 ft, 36°24'00"N, 118°59'00"W, 20 Mar 1998, *Shevock & York 16902* (CAS). **Tuolumne Co.:** Mather Rd west of Abernathy Meadow, 4365 ft, 37°52'21"N, 119°54'47"W, 25 Apr 2010, *Shevock, Colwell & Haas 34875* (CAS); South Fork Tuolumne River off Hwy 120 at Rainbow Pool, 2750 ft, 37°49'15"N, 120°00'46"W, 6 Apr 2013, *Shevock & Dalton 42007* (CAS); Stanislaus National Forest, Tuolumne Wild & Scenic River at junction with Clavey River, 1060 ft, 37°53'01"N, 120°09'12"W, 5 Aug 2011, *Shevock, Hutten & Haas 38582* (CAS, KRAM); between Indian Creek and Big Creek, 920 ft, 37°53'47"N, 120°12'58"W, 6 Aug 2011, *Shevock, Hutten & Haas 38597* (CAS); Sonnet Mine, 2955 ft, 1 Aug 2007, *Willits 232* (CAS). **Yuba Co.:** Daugherty Hill Wildlife Area about four miles NE of Loma Rica, 796 ft, 39°20'40"N, 121°21'52"W, 28 Feb 2005, *Ahart 11558* (CAS, CHSC). USA, MONTANA. **Lincoln Co.:** near Airport Rd in Tobacco Valley, 800 m, 48°56'N, 115°05'W, 7 Apr 2000, *Spribille 9695* (private herbarium of JR Spence). USA, OREGON. **Wasco Co.:** near Rte 218 just west of Clarno, 405 m, 44°54'N, 120°28'W, 23 Mar 2008, *Kellman & Shevock 5779* (CAS); Memaloose State Park, north of a rest area along I-84 east of Mosier, 45 m, 45°41'N, 121°20'W, 27 Mar 2008, *Kellman & Shevock 5849* (CAS). **Wheeler Co.:** above Hwy 218 between mile markers 31 & 32, east of Clarno unit of John Day National Monument, 650 m, 44°54'N, 120°19'W, 23 Mar 2008, *Shevock & Kellman 31604* (CAS).

#### DISTRIBUTION AND ECOLOGY

Forming turfs on acidic rock, often granite or basalt, rarely on sandstone, or on soil, in generally sunny locations, in grasslands, chaparral and

open conifer-oak forests, below 1500 m, usually away from the influence of maritime fog, primarily Californian but also known from Oregon and Montana.

Associated bryophytes are *Didymodon nicholsonii* Culm., *Grimmia laevigata* (Brid.) Brid., and *G. trichophylla* Grev.

#### ETYMOLOGY

The name derives from the wine purple color of the plants including the leaves and stems.

#### DISCUSSION

*Gemmabryum vinosum* is easily recognized in the field by its burgundy colored leaves with the lighter colored awns diverging from the apex. The plants do have a certain shininess, but not the metallic iridescence of *Imbribryum alpinum* (With.) Pedersen or *Pohlia cruda* (Hedw.) Lindb. It has a scattered distribution in the drier portions of the West, and it is so distinctive that it is surprising that it has not been described previously.

Several collections have shown bulbil-like buds produced singly in the leaf axils of the coma. These buds appear to be incipient innovations, but in the two plants where they have been seen, there were no perichaetia or perigonia present. Furthermore, it is not clear that the buds have clear excision mechanisms — all have remained attached to the stem during dissection, and there does seem to be a progression of growth. The smallest buds are spherical with leaf primordial similar to those of *Gemmabryum barnesii* (Wood) J.R. Spence. Larger buds have similar leaf primordia, but the basal portion of the bud extends like a stem elongation, as found in *G. caespiticium* (Hedw.) J.R. Spence. Even larger buds have tiny leaves complete with the awns of the adult leaves. It is possible that these innovations are finally released, because on several plants we have seen short plants with rhizoids, clustered around, but not attached to the lower stem of the main plant.

*Gemmabryum vinosum* has been confused with sterile material of *Rosulabryum erythroloma* (Kindb.) J.R. Spence, but can be distinguished by leaves imbricate and appressed when dry (vs. leaves twisted or contorted when dry in *R. erythroloma*), costa excurrent into the awn (vs. costa variable and often ending before the apex in *R. erythroloma*), leaves with only a weak border (vs. leaves with a distinct limbidium in *R. erythroloma*). Fertile material of *R. erythroloma* is also strongly rosulate. The species differs from *Imbribryum miniatum* (Lesq.) J.R. Spence by the rosulate plants (vs. plants julaceous in *I. miniatum*), presence of hairpoint (vs. apex obtuse in *I. miniatum*), and the upper cells more or less

parallel to the costa (vs. upper cells divergent from the costa in *I. miniatum*). *Rosulabryum gemmascens* (Kindb.) J.R. Spence produces slender innovations of ovate awned leaves, which are often reddish, and was thus confused with *G. vinosum* by Spence (1988). However, the awn of the innovation leaves is usually colored, while fertile *R. gemmascens* also has rosulate obovate leaves and a cylindrical capsule with a well-developed peristome.

#### TAXONOMIC TREATMENT

***Gemmabryum californicum*** (Sullivant) J.R. Spence, *Phytologia* 89: 111. 2007, (Fig. 3). *Bryum californicum* Sull. Exploration and Surveys for a Railroad Route from the Mississippi River to the Pacific Ocean, Description of the Mosses and Liverworts 4(5): 188. 6. 1856.—Type: USA, California, Whipple Survey, 25 April 1854, *J. M. Bigelow* s.n. (FH!).

Described by Sullivant (1856) for material collected in California, this species was sunk into synonymy under *G. dichotomum* (as *Bryum bicolor* Dicks.) by early workers (see below). However, collections of some material labeled as *G. dichotomum* showed very unusual features, including extremely small and abundant propagula in the upper leaf axils. Our studies have shown this material to be very similar to the type and distinct from others in the complex. Below we provide the first detailed descriptions of this fascinating species.

Plants very small, up to five mm tall, but usually around one mm tall, sometimes evenly foliate below the ovoid terminal tuft, but more commonly ovoid gemmiform or barely foliate below the ovoid terminal tuft, golden green. Branched, or more commonly simple. Leaves tightly appressed both wet and dry, ovate, concave, 0.6–0.8 × 0.6–0.7 mm. Margins erect and unbordered, entire. Costa single, straight and without spurs, percurrent in a short apiculus, approximately 50 μm wide at the base and not much tapered above. Distal laminal cells irregularly hexagonal, 2–4:1, 30–46 × 10–14 μm, sometimes with thick walls. Proximal laminal cells short rectangular to quadrate, 1–1.5:1, not differentiated at the margin. Asexual reproductive bodies numerous, variously shaped (often obconical), multicellular gemmae produced in leaf axils and eventually obscuring the plant. Gemmae often massed around the plant. Rhizoidal tubers not seen. Sexual condition dioicous. Seta smooth throughout, pale at the base and getting progressively redder above, up to 15 mm long. Capsules variable from horizontal to suberect, deep red, short ovoid to short cylindrical, merely wrinkled when dry, usually bulging in the middle with a thick and somewhat wrinkled neck

roughly the same diameter as the mouth, 1–1.7 mm long. Stomata restricted to the neck. Operculum short conic. Annulus revoluble. Exostome teeth narrowly triangular with a somewhat long-acuminate apex, orange at the base and hyaline above; variably roughened. Endostome united in the basal half, segments very irregular in shape, about or slightly shorter than the exostome, hyaline, cilia absent. Exothecial cells very irregularly shaped, longitudinally or transversely elongated, with thick red walls. Spores 11–15 μm in diameter, smooth or slightly roughened, with an easily visible, large organelle.

Other specimens examined: USA, CALIFORNIA. **Butte Co.:** Bidwell Park, 21 April 2006, *Shevock & Norris 27908* (CAS). **Monterey Co.:** Carmel Valley Rd, 290 m, 36°16'37"N, 121°27'12"W, 2 Aug 2003, *Kellman 3099* (CAS); near junction of Gigling Rd and 8<sup>th</sup> Avenue, Fort Ord, 105 m, 36°38'35"N, 121°47'17"W, 22 Jan 2006, *Kellman 4186* (CAS); one road bank along Robinson Canyon Rd approximately five miles from the bridge over the Carmel River, 450 m, 36°28'N, 121°48'W, 11 Mar 2007, *Kellman 5303* (CAS); above SR198 approximately 1.5 miles east of San Lucas, 145 m, 36°08'N, 121°00'W, 17 Feb 2008, *Kellman 5708* (CAS); Ventana Wilderness, Los Padres National Forest, Arroyo Seco Trail, 700 m, 36°07'00"N, 121°28'31"W, 3 Feb 2007, *Kellman & Shevock 5226* (CAS); Robinson Canyon Rd 4.3 miles from the bridge over the Carmel River, 1 415 m, 36°28'N, 121°48'W, 9 Feb 2007, *Kellman & Shevock 5263* (CAS); road bank along Robinson Canyon Rd 3.7 miles from the bridge over the Carmel River, 330 m, 36°29'N, 121°48'W, 19 Feb 2007, *Kellman & Shevock 5270* (CAS). **Santa Cruz Co.:** small plateau above the Scotts Valley High School, south exposure, 250 m, 37°04'21"N, 122°00'31"W, 10 Mar 2001, *Kellman 1350* (CAS); Cupcake Hill behind Scotts Valley High School off Glenwood Drive, 245 m, 37°04'21"N, 122°00'32"W, 27 Aug 2008, *Kellman 5861* (CAS); Big Basin State Park, below Basin Trail and China Grade Rd, 685 m, 37°12'41"N, 122°12'43"W, 20 Jul 2008, *Kellman 5875* (CAS); Hwy 9 near mile marker 22.6 between Boulder Creek and Hwy 35, 500 m, 37°13'40"N, 122°08'58"W, 24 Jan 2009, *Kellman 5990* (CAS, MO, NY, UC). **Tuolumne Co.:** along Hwy 108, 6.1 miles east of Mi-Wok Ranger Station, 1675 m, 38°08'N, 120°05'W, 6 Sep 1999, *Shevock 18584* (CAS).

#### DISTRIBUTION AND ECOLOGY

Widely scattered to forming dense turfs on sunny sandstone or rarely volcanic rock or thin soil over rock, sometimes in sandy sites, in open vegetation or open oak-pine forests, ≤1000 m, endemic to California.



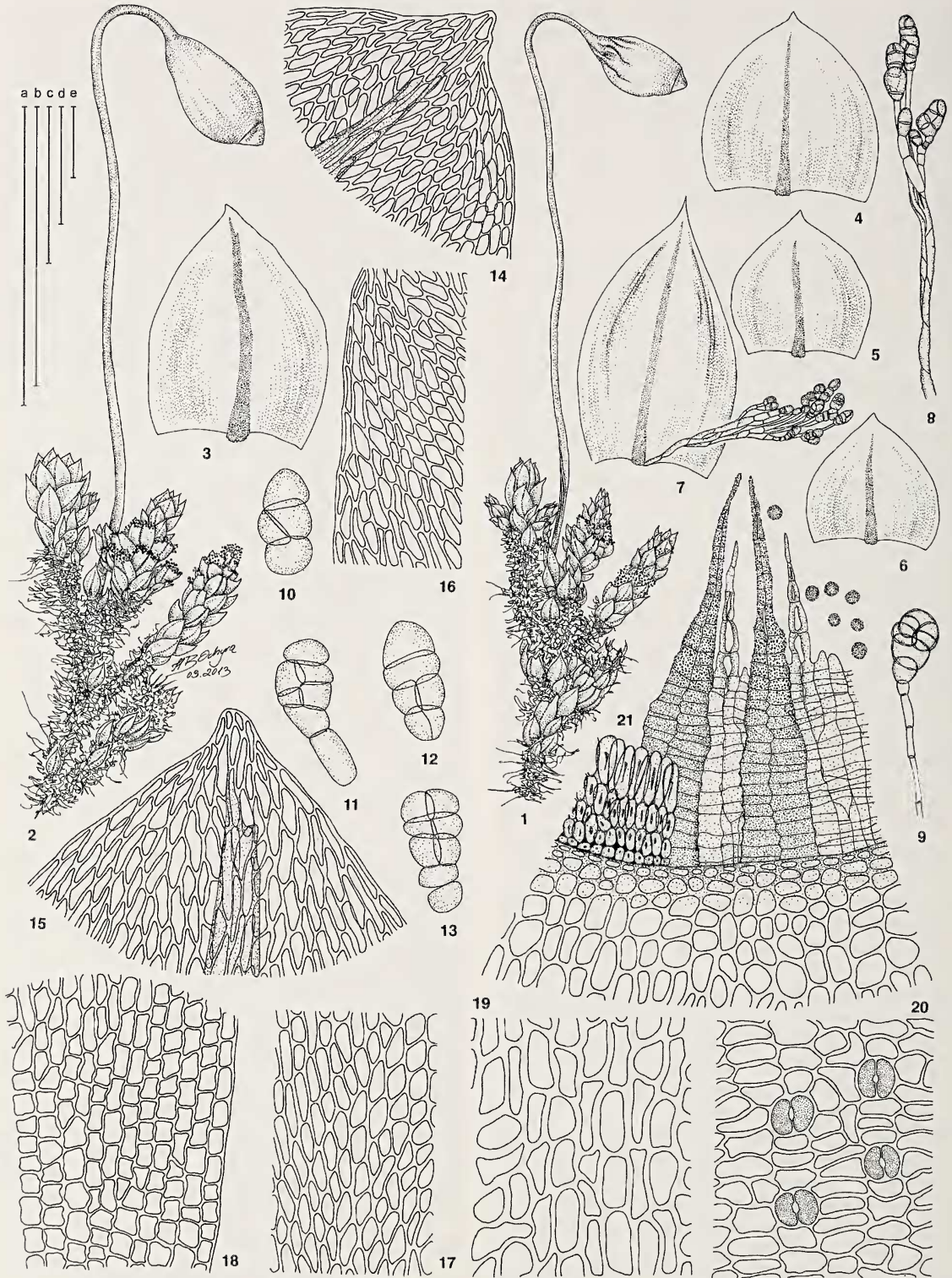


FIG. 3. *Gemmabryum californicum* (Sull.) J.R. Spence. 1. Fertile plant, dry. 2. Same, wet. 3-6. Leaves. 7. Leaf with rhizoid at base bearing tubers. 8-9. Tubers on appendages arising from rhizoids. 10-13. Tubers. 14-15. Leaf apices. 16. Mid-leaf cells at margin. 17. Mid-leaf cells. 18. Basal cells. 19. Mid-urn exothelial cells. 20. Exothelial cells at base of urn and stomata. 21. Exothelial cells at orifice, annulus, portion of peristome and spores. (All from *Kellman 5861*, CAS). Scale bars: a - 1 mm (7); b - 1 mm (3-6); c (100  $\mu$ m (10-13); d - 100  $\mu$ m (9, 14-21) and 200  $\mu$ m (8); d - 1 mm (1-2).

Associated bryophytes are *Didymodon brachyphyllus* (Sull. in Whipple) Zand. *Cephaloziella divaricata* (Sm.) Schiffn., and *Rosulabryum canariense* (Bridel) Ochyra.

#### DISCUSSION

*Gemmabryum californicum* can be recognized from the following combination of characteristics: golden-brown leaves that are tightly appressed in comal tufts either wet or dry, short ovoid capsules, and the common presence of irregularly shaped, multicellular gemmae produced in the leaf axils. It can only be confused with *G. brassicoides*. To separate these two plants, see notes in the discussion under *G. brassicoides*.

Originally, we thought to describe *G. californicum* as a new species, especially with the discovery of the gemmae, unique in *Bryum* sensu lato. However, because the type specimen of *Bryum californicum*, which has no gemmae, but otherwise strongly resembles the plants with capsules and gemmae, it became clear that the only prudent course of action is to label the gemmiferous plants *G. californicum*, instead of creating a new name.

There has been some controversy about the status of *Bryum californicum* since it was first described. Kindberg (1897) thought that it was a subspecies of *Bryum atropurpureum* (Bruch. & Schimp.), a taxon that was later synonymized with *Bryum bicolor* Dicks. by Corley et al. (1981). Many present day authorities (Ochi 1980, 1985; Allen 2002; Anderson, Crum and Buck 1990; Iwatzuki 1991; Ignatov and Efonina 1992) feel that the proper name for *B. bicolor* is *B. dichotomum*. Podpera (1956) followed Corley et al., and made the new combination *Bryum bicolor* subsp. *californicum*. Whether or not you choose *bicolor* or *dichotomum* (the latter epithet for BFNA), that taxon is known by its large axillary bulbils with leaf primordia in the upper third of the bulbil.

This confusion can easily be attributed to the type specimen at Farlow Herbarium (FH) and ultimately to Sullivant's liberal concept of *Bryum californicum*. There are three specimens attached to the card with the type, all from Herbarium Sullivant. One is labeled as the type specimen with the following information on the label: California, Whipple Survey J. M. Bigelow, 25 April 1854. This plant matches the drawing and description in Sullivant's paper.

The second collection was made by Bolander, with no date or location other than California. This plant has leaves that are not appressed at the apex like the type, but is similar in areolation and sporophyte. The third collection has a typed label enclosed that reads: Collected in Southern California (between 32° and 36°N. lat. and 114°

and 121°W. long.) on the Mexican Boundary Survey; by C. C. Parry, under the direction of Maj. W. H. Emory, Chief astronomer of the Commission. The outer label adds the years 1849–52. This third collection has only short capsules in common with the type specimen, as the leaves are not at all appressed to the stem, and are more like a *Ptychostomum* or narrow leaved *Rosulabryum*. Apparently Sullivant was willing to place any *Bryum* with a short capsule under the name *californicum*. It is the authors' opinion that only the type specimen is actually *G. californicum*, albeit without the gemmae.

Nonetheless, the earlier synonymies require that we defend separation from *Bryum dichotomum*. As stated above, that taxon has short capsules very similar to *G. californicum*. However, the bulbils from that plant are very large and complex (Vanderpoorten and Zartman 2002). The gemmae from *G. californicum* are hardly organized beyond an obclavoid conglomeration of cells. Moreover, in *Bryum dichotomum*, the leaves, that may be appressed when dry in some forms, always relax somewhat when wet. This is not the case in *G. californicum*, where the leaves are in tight comal tufts wet or dry.

We believe that the axillary gemmae of *G. californicum* are actually neotonous forms of the bulbils in the *Bryum dichotomum* complex. Although no controlled growth experiments have been done for confirmation, observation of plants in the field seem to indicate that gemmae growth can be so explosive that it forces the apex of plant to fall off, exposing a rosette of remaining leaves surrounded by hundreds of gemmae.

Although currently considered endemic to California, the species should be sought for in coastal Mediterranean climate areas of Oregon, Washington, and British Columbia.

#### CONCLUSIONS

Fieldwork during the last 20 years has revealed many moss species new to science from the California Floristic Province. Within the traditional Bryaceae, the following species have been recently described (including in this paper): *Gemmabryum brassicoides*, *G. vinosum*, *Imbribryum torenii*, *Pohlia robertsonii*, *Haplodontium tehamense*, *Mielichhoferia shevockii*, and *Ptychostomum pacificum*. Additional undescribed species from California in *Anomobryum*, *Gemmabryum*, *Plagiobryoides*, and *Rosulabryum* are awaiting formal publication. Overall, at least 60 known species have been documented from California within the Bryaceae (excluding *Pohlia* and its relatives which have been recently placed in resurrected Mielichhoferiaceae for BFNA), representing almost 10% of the moss flora,



and making the state perhaps the most diverse in temperate Northern Hemisphere (Spence 2014).

With the recognition of three new species, California also becomes one of the two major centers of diversity in the Northern Hemisphere for *Gemmabryum* section *Gemmabryum*, with the other center being western and southern Europe. Including traditionally recognized species, there

are now six known from the state, *G. barnesii*, *G. brassicoides*, *G. californicum*, *G. dichotomum* (= *G. bicolor*), *G. gemmiferum*, and *G. gemmilucens*. This section appears to be most diverse in Mediterranean-climate regions, at least in the Northern Hemisphere. Preliminary work (J.R. Spence unpublished) indicates that the Mediterranean-climate regions of Chile may also represent an important center of diversity.

KEY TO SPECIES OF *GEMMABRYUM* SECTION *GEMMABRYUM* IN CALIFORNIA

The following key includes all species of the section related to *G. dichotomum* found in California and also includes *G. vinosum*.

- 1. Plants lacking bulbils, producing tubers on rhizoids, shoots somewhat elongate, leaves not imbricate, often somewhat twisted or contorted when dry, if imbricate then rhizoidal tubers abundantly produced, small, spherical to pyriform, brown Section *Tuberibryum* [not in key; see Spence 2014]
- 1'. Plants with 1–many bulbils in axils of upper innovation leaves, shoots budlike or occasionally elongate, leaves imbricate, not contorted or twisted when dry; tubers rarely produced (strongly gemmiform plants lacking tubers and bulbils key here) . . . . . 2
  - 2. Plants with bulbils in upper leaf axils . . . . . 3
  - 2'. Plants lacking bulbils, even in absence of capsules . . . . . 7
    - 3. Bulbils large, (200) 300–750 µm, leafy primordia rising from near base or mid-bulbil, 1–2 per leaf axil. . . . . *Gemmabryum dichotomum*
    - 3'. Bulbils smaller, (50)100–400 µm, leafy primordia from upper 1/3 of bulbil to short and peglike or primordia lacking, 1–25 or more per leaf axil . . . . . 4
      - 4. Bulbils small, 60–80 µm, key-hole shaped to obconical, cells in 2–4 tiers, numerous, often 100's. . . . . *Gemmabryum californicum*
      - 4'. Bulbils larger, typically >100 µm, cylindrical to top-shaped or round, fewer . . . . . 5
        - 5. Bulbils small, 100–200 µm, round or cylindric, primordia lacking or very short and peg-like. . . . . *Gemmabryum gemmilucens*
        - 5'. Bulbils mostly 150–350 µm, pyriform to conic, distinct primordia present . . . . . 6
          - 6. Bulbils 150–250 µm long, primordia narrow, acute and tooth-like . . . . . *Gemmabryum gemmiferum*
          - 6'. Bulbils mostly >200 µm, primordia broad, obtuse, leaf-like *Gemmabryum barnesii*
          - 7. Leaves usually red, distal lamina often hyaline, costa strong, long excurrent, hairpoint colored, reddish, sometimes spinulose and hyaline at tip; rhizoidal tubers sometimes present . . . . . *Gemmabryum vinosum*
          - 7'. Leaves green, golden or yellow-green, distal lamina not hyaline, costa not reaching apex to short excurrent in stout colored point, not spinulose; tubers unknown . . . . . *Gemmabryum brassicoides*

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